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TITLE

METHOD OF OBTAINING STABLE CONDITIONS FOR THE EVAPORATION TEMPERATURE OF A MEDIA TO BE COOLED THROUGH EVAPORATION IN A REFRIGERATING INSTALLATION

BACKGROUND OF THE INVENTION

(1) Field of the Invention

Systems producing cold conditions in cooling and freezing installations, refrigeration, refrigerating machines for cooling and heating operation, refrigerating installations, refrigerating units, heat pumps, air-conditioning systems and so on.

(2) Description of the Related Art

Known forms of refrigeration are, firstly, dry expansion operation, in which the refrigerant undergoes a pressure reduction via an injection valve and is transformed from the liquid state into a liquid/vapor mixture and then to evaporate completely into a vapor in the evaporator, to then leave the evaporator with slightly superheated vapor. This liquid to vapor transition of the refrigerant ~~and thus cool~~ cools down a second medium by heat absorption, and, secondly, by a thermosyphon operation, in which the refrigerant is fed via an equalizing and separating vessel to the evaporator in liquid form either by means of gravity or with the aid of a pump. ~~and where it~~ It is quite possible for the vapor to still ~~to~~ contain liquid fractions at the evaporator outlet, and so there is generally no superheating of the refrigerant at the evaporator outlet.

Under practical conditions, all of these systems suffer from more or less serious disadvantages, which we eliminate by our invention, and consequently achieve considerable energy and cost savings.

Dry expansion systems have the advantage of a simple type of construction and small refrigerant contents.

The evaporator efficiency is substantially ~~influenced~~improved by ~~—least possible~~minimizing the evaporator superheating.

For the ~~condenser~~compressor, however, this is disadvantageous, and ~~its requires~~ correspondingly high superheating provides improved efficiency (improvement in volumetric efficiency, lubrication, etc.).

BRIEF SUMMARY OF THE INVENTION

The point where these two requirements intersect (optimal superheating for the evaporator and ~~condenser~~compressor, which are conversely optimal) gives the maximum system characteristic (most efficient operation).

Our invention succeeds for the first time in breaking through this dependence between minimal superheating for the evaporator and great superheating for the ~~condenser~~compressor.

As a result, this~~This~~ achieves the effect of operating the process for a given refrigerating output Qo with the smallest physically possible mass flow required for this, which leads to considerable economic and energy-related advantages.

A first~~Our~~ innovation relates ~~firstly~~ to the dry expansion system (6) (1), ~~to the dry expansion system (6) (1)~~ with a downstream IHE (2) or internal heat exchanger. ~~(internal heat exchanger, that is to say with a~~ The IHE (2) provides heat exchange between the refrigerant liquid line upstream of the expansion valve on the one hand and the suction vapor downstream of the evaporator on the other hand~~),~~. In other words, the downstream (2) provides heat exchange to the two-stage evaporation system (6) (1 + 2) (a combination of dry expansion system and thermosyphon system, evaporator with IHE) and to further refrigerating installations constructed on this basis.

Depending on operating conditions, relatively great temperature fluctuations on the refrigerant side, upstream of the injection valve (6) (A) and upstream of the ~~condenser~~compressor (5) (B), are typical of these prior art systems.

These temperatures of the refrigerant (upstream of the injection valve (A) and upstream of the ~~condenser~~compressor (B)) are at present not kept constant or ~~exactly~~closely controlled.

Often only the high or suction pressure (Pc/Po) is controlled and/or kept constant, if that.

This leads to more or less great fluctuations and feedback effects (hunting) of the refrigerating system, and consequently, this leads to losses in efficiency and unstable control loops.

The main factors for these fluctuations are, on the one hand, the changed saturation level (x value) of the refrigerant ~~state~~ in the injection valve (6) and in the beginning of the evaporator (1).~~, that~~ The saturation level is changed with the changed temperature of the refrigerant (A). ~~(the~~ The x value is the value that indicates the proportion of already evaporated refrigerant at the beginning of the evaporation process).~~, which~~This saturation level has effects on the performance of the injection valve (6) and the evaporator (1) and on the control response of the injection valve (6) and its performance, or the delivered mass flow of refrigerant. The main factors for these fluctuations are, and on the other hand, the suction vapor at the inlet into the ~~condenser~~compressor (5), where the changed temperature (B), because of the specific volume assigned to the respective temperature (and pressure), has an influence on the volumetric delivery of the ~~condenser~~compressor (5), that is in turn the delivered mass flow.

These mass flows, constantly changing as a result of temperature changes, introduce greater or lesser disturbing factors into the control loop of the refrigerating installation, which lead to fluctuations in the process, and consequently to reductions in performance efficiency.

The objective of the invention is to ~~achieve the following in the case of~~improve the performance efficiency and stable operation for cooling/freezing installations, refrigerating machines for cooling and heating operation, refrigerating installations, refrigerating units, heat pumps and all installations that use refrigerants and refrigerating media~~:~~.

Stable operation of the installation is achieved by~~:~~ the following features:

"Firstly, the temperature of the refrigerant upstream of the injection valve (6) (A) ~~being~~is kept ~~constantly~~constant at a defined temperature value (A)."

"Secondly, the temperature of the refrigerant upstream of the ~~condenser~~compressor (5) (B) ~~being~~is kept at a defined temperature value (B).

"Thirdly, these two measures ~~being~~are used on their own or in combination with each other."

"Fourthly, these three measures ~~leading~~lead to the objective, in combination with a dry expansion valve control (6)~~,~~ ~~conventionally~~ in a conventional fashion on the basis of MSS (minimal stable signal) (P8/T22) with or without the assistance of the IHE (internal heat exchanger) (2) for which the temperature is measured downstream of the evaporator (1) (T22/P8) or downstream of the IHE (2) (T23/P9) or ~~with~~for which the temperature (pressure difference measurement) is measured between the liquid line upstream of the injection valve (6) (T20), or for which the ~~and~~ pressure or temperature measurement is measured downstream of ~~the~~ one or more of the injection valve (6) (P7) (T21), the evaporator (1) (P8) (T22), or the IHE (2) (P9) (T23), the so-called two-stage evaporator control (T20/P7) (T20/P8) or (T20/P9). These varibles may also be measured with ~~or with~~ new expansion valve controls on the basis of the pressure difference (7) over the evaporator (1), the IHE (2), the evaporator and the IHE (1 + 2) or a corresponding reference variable (for example, accumulator)~~, or leading to the objective~~. Additionally, any one of these variables may be used individually.

These measures ~~such as~~of keeping the temperature of the refrigerant liquid upstream of the injection valve constant, and also keeping the temperature of the suction vapor upstream of the ~~condenser~~compressor constant, two-stage evaporator process (with corresponding control) and/or the pressure difference/level control of the injection valve lead to stable operation of the refrigerating installations, (even

with great changes in output), whether these measures are applied on their own or in any desired combination.

If a two-stage evaporator (1 + 2) is used here, minimal temperature differences between the medium to be cooled on the one hand (C/D) and the evaporation temperature ~~to (suction pressure)~~ on the other hand can also be ~~additionally~~ achieved.

This temperature difference may, in any event, be less than the temperature difference if the refrigerant leaves the evaporator (1) "superheated" (P8/T22) in a dry expansion operation.

What is novel about our invention is that the temperature of the liquid refrigerant upstream of the injection valve is continuously maintained~~kept constantly~~ at a predetermined value (A).

The liquid refrigerant may be maintained~~It can be kept constant~~ in this way by various measures. For the sake of simplicity, we describe keeping the liquid refrigerant predetermined value (A)~~keeping it~~ constant by means of a heat exchanger (4) in the refrigerant liquid line upstream of the injection valve, which keeps the outlet temperature of the liquid refrigerant constant by a second medium. ~~The~~This second medium used for keeping the refrigerant liquid temperature constant may in this case be of any kind desired (gaseous, liquid, etc.).

One possibility for keeping the refrigerant liquid temperature upstream of the injection valve (A) constant may be through cooling the medium at flow point (D)~~that the flow (D) of the medium to be cooled, for~~. For example, water, brine, etc., is passed through a heat exchanger (4), in which the refrigerant is conducted in either co-flow, cross-flow or counter ~~co-current, cross-current or counter-current~~ flow, etc., on the second side of the heat exchanger.

Other possibilities for stabilizing the refrigerant liquid temperature upstream of the injection valve (A) may also take place, for example, by means of stores, latent stores, masses of inertia or storage masses (13) or further measures.

The refrigerant liquid temperature upstream of the injection valve (A) may also be controlled by means of mass flow control of the refrigerant liquid (9) through the IHE (2) or of the suction vapor (12) through the IHE (2)~~,~~ ~~(~~ however, depending on conditions, sometimes only partial mass flows flow through the IHE (2)~~)~~.

What is also novel about the invention is that the refrigerant liquid temperature upstream of the injection valve (6) (A) is kept constant.

What is also novel about the invention is that the refrigerant liquid temperature, especially in the case of the two-stage evaporation process (1 + 2), upstream of the injection valve (6) (A) is not only kept constant, but at a very low value, which is close to or on the left-hand limiting curve of the log ~~(p), h~~p-h (pressure-enthalpy) diagram for refrigerants~~;~~. ~~(~~ As a result, the refrigerant therefore enters the evaporator (1) in liquid form as in the case of a thermosyphon system or with minimal vapor content~~)~~.

What is also novel about the invention is that the refrigerant suction vapor temperature at the inlet into the ~~condenser~~compressor (5) (B) is kept constant.

~~Measures for this~~This may be analogous to keeping the refrigerant liquid upstream of the injection valve (6) (A) constant~~:~~. ~~Therefore, heat~~ Heat exchangers or storage masses or masses of inertia are used for keeping the suction vapor temperature constant.

Furthermore, there are refrigerating systems ~~with inserted~~ utilizing IHEs (2) (two-stage evaporators, semi-flooded systems) which supercool the liquid refrigerant upstream of the injection valve (A) ~~(and the measures for keeping~~ and maintain the temperature constant~~)~~ and superheat (B) the suction vapor downstream of the evaporator (1) (2).

Keeping the suction vapor temperature constant may also be performed by means ~~of measures~~ such as external supercoolers (3), which control the refrigerant liquid inlet temperature into the IHE (2) (8) and in this way control the suction vapor temperature from the IHE (2) (B).

Keeping the suction vapor temperature constant may also be controlled by means of mass flow control of the refrigerant liquid (9) through the IHE (2) or of the suction vapor (12) through the IHE (2).

Keeping the suction vapor temperature constant may also be achieved by greater or lesser "flooding" of the IHE (2) ~~(only in the two-stage evaporation process)~~. <u>However, this is utilized only in the two-stage evaporation process.</u>

The "flooding" of the IHE (2) may in this case take place by means of <u>1)</u> a temperature control of the suction vapor at the inlet of the ~~condenser~~<u>compressor</u> (two-stage evaporator control) (T23), <u>2)</u> level control (7) directly by the evaporator (1), <u>3)</u> IHEs (2) individually or together or <u>4)</u> by means of a reference variable such as, for example, the accumulator ~~or other~~ or <u>by</u> a pressure difference control (7) directly by <u>using</u> the evaporator (1) IHEs (2) individually or together.

All these described measures may be used individually or combined in any way desired.

The invention is substantially based on keeping the refrigerant liquid temperature upstream of the injection valve (A) and the suction vapor temperature upstream of the ~~condenser~~<u>compressor</u> (B) constantly at any desired value (within the limits of what is physically possible but as and when required up to the physical limits) by suitable measures.

The constant temperature of the refrigerant at ~~these~~ two points in the refrigerating system<u>, in particular, the</u> ~~(~~refrigerant liquid upstream of the injection valve (A)~~,~~ <u>and</u> suction vapor upstream of the ~~condenser~~<u>compressor</u> (B)~~)~~, achieves the effect

of stable operation~~, and, if~~ If desired, this may also provide minimal temperature differences between the media to be cooled at the evaporator (1) inlet (C) and outlet (D)~~(inlet/outlet temperature (C/D)~~ on the one hand, and ~~inlet and/or outlet temperature in relation to~~ the media evaporation temperature ~~(C/D in relation to to)~~ at the inlet (C) and/or the outlet (D) on the other hand).

BRIEF DESCRIPTION OF THE DRAWINGS

- Figure 1: A schematic of an arrangement showing possible solutions for monitoring the refrigerant temperatures upstream of the injection valve and ~~condenser~~compressor.
- Figure 2: A schematic of an arrangement showing possible solutions for monitoring the refrigerant temperatures upstream of the injection valve and ~~condenser~~compressor without auxiliary pumps in the secondary circuit.
- Figure 3: A schematic of an arrangement showing possible solutions for monitoring the refrigerant temperatures upstream of the injection valve and ~~condenser~~compressor in dry expansion operation without the IHE.
- Figure 4: A schematic of an arrangement showing possible solutions for monitoring the refrigerant temperatures upstream of the injection valve and ~~condenser~~compressor in dry expansion operation with IHE and/or two-stage evaporation.
- Figure 5: A schematic of an arrangement showing possible solutions for monitoring the refrigerant temperatures upstream of the injection valve and ~~condenser~~compressor in dry expansion operation with IHE and/or two-stage evaporation with external supercooler.
- Figure 6: A schematic of an arrangement showing possible solutions for monitoring the refrigerant temperatures upstream of the injection valve and ~~condenser~~compressor in dry expansion operation with IHE and/or two-stage evaporation with external supercooler and storage mass or mass of inertia for keeping constant the temperature of the refrigerant upstream of the injection valve instead of the heat exchanger.
- Figure 7: A pressure-enthalpy (p-h) diagram~~log (p), h diagram~~.

~~The diagrams explain the sense and make no claim to be exhaustive.~~ These figures are presented to show illustrative embodiments and are in no way considered to be exhaustive. The valves, heat exchangers, etc. may be used individually or combined in every possible form. No further illustrations are provided and reference is made to the text.

DETAILED DESCRIPTION OF THE INVENTION

The invention is based on achieving stable operation of refrigerating installations with small temperature differences of the media to be cooled, and consequently higher efficiencies. ~~(and thereby~~ This results in highly efficient evaporation in refrigerating installations~~)~~.

The method of producing cold conditions is supplemented or modified to the novel extent that, in addition to the monitored suction and high pressures in refrigerating systems, the temperature of the liquid refrigerant upstream of the injection valve (A) and the temperature of the suction vapor upstream of the ~~condenser~~compressor inlet (B) is monitored, controlled and kept constant.

Monitoring the refrigerant temperature upstream of the injection valve (A) ~~has the effect of producing defined~~allows control of the saturation states in the refrigerant mixture (liquid/vapor). ~~These defined states~~This control in the refrigerant ~~lead~~leads to stable conditions in the refrigerating circuit.

~~We obtain the~~The same effect may be achieved by monitoring the temperature and keeping constant the suction vapor temperature at the ~~condenser~~compressor inlet (B).

By stabilizing these two temperatures, which are the temperatures upstream of the injection valve and the temperature at the inlet of the compressor, and the associated respective states of the respective refrigerant at these two points in the refrigerating circuit, we achieve stable conditions and prevent feedback effects in the control equipment and hunting of the system.~~, and consequently less~~ As a result, there are fewer disturbances, which leads to a stable control loop and

consequently to stable operation of the refrigerating installations and ~~consequently~~ to highly efficient evaporation.

Such a stable operation~~The more stable operation obtained~~ has the effect of producing energy and cost savings and making it possible to operate processes with much smaller temperature differences of the media to be cooled in relation to the respective evaporation temperatures, especially in combination with the two-stage evaporation technique (1 + 2).

As a result, processes can be operated in a simple and low-cost manner that is not possible at present in this way.

~~These two temperatures (A + B) and~~ The temperature A upstream of the injection valve and the temperature B at the inlet of the compressor and the associated refrigerant states can be monitored and stabilized in many possible ways.

The enumeration of possibilities is analogously restricted in this patent specification to just a few.

The innovation is the monitoring of the two described refrigerant states (A + B).~~,~~ ~~irrespective~~ Irrespective of the method by which this is achieved, only one or the other measure ~~(A or B or 7)~~(temperature A, temperature B, or pressure differential 7) ~~having to~~ must be taken, depending on the application. It is consequently possible to arrive at the desired result just by the monitoring of the temperature of the liquid refrigerant upstream of the injection valve (A) or ~~the~~ monitoring ~~of~~ the temperature of the suction vapor upstream of the ~~condenser~~compressor (B) or by the monitoring of the liquid refrigerant pressure upstream of the injection valve and the monitoring of the temperature of the suction vapor (A + B).

Suitable measures for monitoring the temperature of the refrigerant upstream of the injection valve are:

1. Keeping the temperature of the refrigerant upstream of the injection valve constant by using a secondary medium ~~by means of~~ through a heat exchanger (4).

2. Keeping the temperature of the liquid refrigerant upstream of the injection valve constant (slow to react) by using a mass (13) which may be ~~(~~liquid, solid, gaseous or mixed between these states of aggregation~~)~~.

3. Keeping the temperature of the liquid refrigerant upstream of the injection valve constant, especially when using an IHE or applying the two-stage evaporation process, ~~by means of~~through use of a control valve (9). This control passes only a specific mass flow through the IHE or the second stage of the two-stage evaporation and the remaining mass flow (E) passes directly or indirectly to the injection valve.~~, it being~~ Therefore, it is possible for the mass flow (E) ~~that is made~~ to pass the IHE or the second stage of the two-stage evaporation to be cooled, heated or kept ~~the same~~at the same temperature.

Suitable measures for monitoring the temperature of the refrigerant upstream of the ~~condenser~~compressor are:

4. Keeping the temperature of the suction vapor upstream of the ~~condenser~~compressor (B) constant by using a secondary medium by means of a heat ~~exchange~~exchanger.

5. Keeping the temperature of the suction vapor upstream of the ~~condenser~~compressor constant (slow to react) by using a mass (liquid, solid, gaseous or mixed between these states of aggregation).

6. Keeping the temperature of the suction vapor upstream of the ~~condenser~~compressor constant, especially when using an IHE or applying the two-stage evaporation process, by means ~~of use~~ of a control valve (8), (12) and/or (9). Control valves 9 and 12 pass~~This control (12) (9) passes~~ only a

specific mass flow through the IHE (2) or the second stage of the two-stage evaporation and the remaining mass flow (9) travels directly or indirectly to the injection valve (6) or ~~condenser~~compressor (5).

7. By means of a monitored inlet temperature ~~(8)~~ (F) of the liquid refrigerant into the IHE (2) or the second stage of the two-stage evaporator, for example using an external refrigerant liquid supercooler (3) or the like.

8. By means of a monitored filling level of the refrigerant to be liquefied in the evaporator or in the IHE or in the second stage of the two-stage evaporator, for example by means of level control (7) or pressure difference measurement (7) or suction vapor temperature control (T23) upstream of the ~~condenser~~compressor.~~, it being~~ Therefore, it is possible for the level control to ~~take place~~ occur by means of the evaporator, the IHE or the second stage of the two-stage evaporator individually and/or the evaporator alone or in combination with the IHE or by means of the second stage of the two-stage evaporator or a reference object, for example an accumulator.

9. Especially in the case of a refrigerating system with two-stage evaporation (1 + 2), the control ~~and incorporation~~ can be performed as follows (combinations and variants thereof are also possible): injection valve may be controlled by~~control by means of~~ detecting the temperature of the refrigerant 1) upstream of the injection valve (T20), ~~and~~ the pressure/temperature downstream of the injection valve (T21/P7), 2) the pressure/temperature between the first and the second evaporator stages (P8/T22), or 3) the pressure/temperature downstream of the second evaporator stage (P9/T23) or combinations thereof. The temperature/pressure difference (T20/P7, P8, P9) serves as a controlled variable for the injection valve (6). A suction vapor temperature detection (T23) upstream of the ~~condenser~~compressor (5) overrides the temperature difference/pressure control (T20/P7, P8, P9) as ~~and when~~ required. As an alternative to the temperature difference/pressure control, a level or pressure difference control (7) for the injection valve (6) may be used.

The temperature upstream of the injection valve is kept constant by means of suitable measures as already described ~~(as described above)~~. Keeping the temperature of the liquid refrigerant upstream of the injection valve constant in this way may take place for example by using a heat exchanger (4) fitted between the liquid line and the medium flow.

A partial mass flow or the entire mass flow of the cooled medium is conducted (10/11) through the heat exchanger (4) in ~~co-current~~ co-flow, ~~counter-current~~counter-flow or ~~cross-current flow~~cross-flow, etc., in relation to the refrigerant liquid.

The medium may in this case be conducted through the exchanger with a controlled or uncontrolled temperature.

The correct dimensioning of the heat exchanger (4) has the effect that the refrigerant liquid upstream of the injection valve (A) is supercooled or kept constant at any desired temperature level, or if desired even at a very low temperature level, which means that the evaporator (1) is fed with liquid refrigerant or with only a small proportion of ~~already evaporated~~vapor refrigerant.

The proportion of ~~already evaporated~~vapor refrigerant in the evaporator can be optimized and set to the evaporator type (1), and consequently ~~to~~will influence the efficiency for starting the evaporation process, with a corresponding temperature of the liquid refrigerant upstream of the injection valve (A).

As an alternative to overriding the injection valve control, based upon ~~by~~ the suction gas temperature, by flooding the second stage of the two-stage evaporator, in the case of excessive suction vapor temperatures upstream of the ~~condenser~~compressor (T23), the refrigerant liquid inlet temperature into the second evaporator stage (IHE) (2) (F) may be limited for example by means of an external supercooler (32). This may be applied in cases of high condensation temperatures.

As an alternative or in combination with this limitation, part of the refrigerant liquid mass flow (E) may be conducted past the second ~~condenser~~compressor stage (IHE) (2), in dependence on the suction vapor temperature (B).